International Journal of Agricultural Science and Research (IJASR)
ISSN(P): 2250-0057; ISSN(E): 2321-0087
Vol. 5, Issue 1, Feb 2015, 87-92

EFFECT OF LAND LEVELLING METHODS ON VOLUME OF EARTHWORK AND MOISTURE UNIFORMITY IN VERTISOLS OF KARNATAKA

P. S. KANANNAVAR[1], P. BALAKRISHNAN[2], RAVINDRAYALIGAR[3], RUDRAGOUDA. C[4] & SHASHIREKHA[5]

[1]Assistant Professor, Department of Soil and Water Engineering, College of Agricultural Engineering, University of Agricultural Sciences, Raichur, Karnataka, India

[2]Dean, Department of Agricultural Engineering, College of Agricultural Engineering, University of Agricultural Sciences, Raichur, Karnataka, India

[3]Research Scholar, Department of Soil and Water Engineering, College of Agricultural Engineering, University of Agricultural Sciences, Raichur, Karnataka, India

[4]Research Scholar, Department of Farm Machinery and Power Engineering, G. B. Pant University of Agriculture and Technology, Pantanangar, Uttarakhand, India

[5]Department of Water Resources and Environmental Technology, Jawaharlal Nehru Technology University, Hyderabad, India

ABSTRACT

Land development is the need of the hour for increasing the food production by providing innovative techniques to address spatial variability prevalent in agricultural fields. Land levelling is the first step for better land development. The results of the study, conducted in research farms of University of Agricultural Sciences (UAS) Raichur to find the effect of levelling methods *viz.*, traditional and laser levelling methods on moisture uniformity in vertisols of Karnataka, showed that the standard deviation of reduced levels of grid points of 10m x10m before levelling was 11.42 cm and after using the laser leveller was 1.43 cm. The standard deviation of reduced levels before levelling was 14.43 cm and 8.63 cm after levelling using the traditional leveller for levelling. In case of traditional levelling the average volume of earthwork (cut and fill) was reduced from 266 cubic meters to 158.86 cubic meters and in case of laser levelling, it was reduced from 259.2 cubic meters to 28.28 cubic meters. The per cent reduction in volume of earthwork was 40.27 % and 89.08 % in traditional and laser levelling methods respectively. From highest per cent reduction of earth work higher accuracy of grading was observed when the fields were graded with the laser leveller which led to uniform topography of land and uniform distribution of moisture storage in the field. After rainfall of 19 mm and 70 mm at different durations, the average uniformity coefficients of moisture distribution and standard deviation in case of precision leveled fields were found to be 92.90 % and 3.73 %, respectively. The same were 75.90 % and 9.11 %, respectively in case of traditional levelling.

KEYWORDS: Laser Levelling, Traditional Levelling, Volume of Earth Work and Moisture Uniformity

INTRODUCTION

Land development is the need of the hour for increasing the food production by providing innovative techniques to address spatial variability prevalent in agricultural fields. Land levelling is the first step for better land development. In recent years; the conventional levelling technologies in production system have been leading to deterioration of soil

health and declining farm profitability due to high inputs of water, nutrient and labour. Laser guided land levelling is an upcoming concept in agriculture production system in the dry zones of the Karnataka. This technique is prerequisite for precision agriculture and plays an important role in augmenting food security with the changing scenario of climate. Laser levelling can be made possible application of modern farm technology in farming. It is a new paradigm shift from traditional management practices of the soil and crop with spatial variability to suit variation in resource condition. The precision of levelling which depends on volume of earthwork in the cut or fill with respect to the desired plane in an area results into formation of uniform topography of land surface which in turn helps in holding of moisture uniformly over the entire field. Traditional methods of levelling land are not accurate as they depend purely on driver's judgement (Rickman, 2002). This leads to more field variability. Cook (1960) reported that a significant (20-25 %) amount of irrigation water was lost during its application at the farm due to poor farm designing and unevenness of the fields. The mechanization of most agricultural work requires proper land levelling and land consolidation before planting, which alters the natural drainage and soil hydrology as well as the soil properties (Ramos and Casasnovas, 2007). Paddy being a major food crop in Tungabhadra Project (TBP) Command area needs precise land development to reduce the wastage of water. This can be accomplished by laser land levelling techniques to conserve more valuable resources *viz.,* soil and water. Though laser levelling is state of the art technique and is being commonly used in civil engineering projects, but very rare usage is observed in farmers' fields of Karnataka (Kanannavar *et al.* 2009). In this regard, the present study on effect of land levelling methods on quantity of earthwork and uniformity of moisture distribution was undertaken in research farms of UAS, Raichur, Karnataka.

MATERIALS AND METHODS

For comparative evaluation of laser leveller (levelling with a Laser guided land leveller) with the traditional system of levelling with respect to quantity of earthwork and uniformity of moisture distribution was carried out. The details of the fields selected are as in "Table 1". In order to eliminate differences in leveller performance due to design of the drag scraper, the same capacity bucket was used for both levellers. "Figure 1" Shows the operation of laser leveller in the field.

For calculation of earthwork before and after levelling, the reduced levels of grid points (10 x10m) were taken in both the fields with a help of topographic survey and are shown in the "Table 2", "Table 3" "Table 4" and "Table 5". For evaluating traditional levelling, the laser system was not used and the hydraulic system was actuated manually.

Figure 1: Laser Guided Land Leveller in Operation

Earthwork Quantity

The volume of earthwork was calculated using four point method (Michael, 2010) for both fields to analyze the extent of levelling from both methods of levelling. To compute volume of fill and volume of cut are calculated using Eq. 1 and Eq. 2 respectively.

$$V_f = \frac{L^2}{4}\frac{(\sum F)^2}{(\sum C + \sum F)} \tag{1}$$

$$V_c = \frac{L^2}{4}\frac{(\sum C)^2}{(\sum C + \sum F)} \tag{2}$$

Where,

V_f = volume of fill, m^3

V_c = volume of cut, m^3

L = grid spacing, m

$\sum C$ = sum of cuts on four corners of grid square, m

$\sum F$ = sum of fills on four corners of grid square, m

Uniformity Coefficient

The spatial variability of moisture distribution was assessed by uniformity coefficient. The moisture distribution uniformity or Uniformity co-efficient was calculated using *Christiansen* formula (Michael, 2011). For moisture distribution studies in both the fields after levelling with one day rainfall event of 19 mm, the moisture samples were taken in center of grid of 10m x 10m for both fields.

$$Cu = 100\left[1 - \frac{\sum X}{mn}\right] \tag{3}$$

Where,

Cu = Uniformity Coefficient or Moisture distribution Uniformity in %

M = Average value of all moisture contents in %

n = Total number of grid points

X = Numerical deviations of individual observations or grid moisture content from the average moisture content.

RESULTS AND DISCUSSIONS

The standard deviation (SD) of the elevations/reduced levels of grid points of the Fields levelled by Laser technology and traditional method is shown in the "Table 1". It was observed that the average standard deviation of reduced levels before levelling corresponding to a plane were 11.41 to 14.43 cm for Field 1 and Field 2, respectively. The high value of standard deviation was mainly due to presence of undulations or slope in the field. The standard

deviation of reduced levels was calculated for each field after levelling to measure the accuracy of levelling. The average standard deviation of reduced levels before levelling was 11.41cm and after levelling was 1.43 cm, for fields levelled with the laser leveller. Whereas in case of traditional levelling, the average standard deviation of reduced levels before levelling was 14.43 cm and after levelling was 8.63 cm. Hence the accuracy of levelling using laser leveller was higher with more precise than conventional method since the standard deviation was only 1.43 cm.

The findings of the present study agree with the study made by Mathankar *et al.*, 2005. The volume of earthwork in conventional and laser levelled fields is shown in “Table 6”. In case of laser levelling, the average volume of earthwork (cut and fill) was reduced from 259.2 m^3 to 28.28 m^3 whereas in case of traditional levelling it was reduced from 266 m^3 to 158.86 m^3. The per cent reduction in volume of earthwork was 89.08 % and 40.27 % in laser and traditional levelling methods, respectively. The reasons for higher standard deviation after levelling with traditional leveller were less volume of earthwork turned over and improper levelling of the field due to operator’s eye judgement of recognising the field levelness. The 87.47 % SD was reduced in the case of laser levelling, whereas, for the traditional method reduction in SD was 40.05 %, which was 45.78 % lower than the laser levelling. Hence the accuracy of levelling using laser leveller was higher with more precision than conventional method since the standard deviation was only 1.43 cm.

For moisture distribution studies in both the fields after levelling with one day rainfall event of 19 mm different durations, the moisture content and its uniformity co-efficient are shown in “Table 7”. The average moisture content was 30.64 % in the laser levelled field and 30.38 % in case of traditional field. The standard deviation of moisture content was found as 3.73 % and 9.11 % in case of laser and traditional levelled fields, respectively. The uniformity co-efficient observed was 92.90 % in laser levelled field and 75.90 % in traditionally levelled field. This shows that higher moisture conservation and uniform distribution of rainfall in laser levelled field compared to traditionally levelled field. Laser levelled method ensures precise land levelling due to higher quantity of earthwork turned over and least standard deviation of elevations of the entire field by reducing variation caused due to undulations or unevenness of the field (Suthakar *et al.,*2008).

CONCLUSIONS

- Considerably higher accuracy of grading was observed when the fields were graded by use of laser guided land leveller in comparison to the traditional levelling method
- The volume of earthwork achieved was the higher (above 85 %) in case of laser levelled fields in comparison to fields with traditional levelling due to improper and non-precise eye judgement of operator.
- Due to higher earthwork turned over and precise levelling, the uniformity coefficient achieved in case of laser levelled field was about 92.90 % in laser levelled field whereas only 75.90 % was possible when field leveled with traditional levelling method.

Table 1: Particulars of Selected Fields

Parameters	Values	
	Field 1: Laser Levelling	Field 2: Conventional Levelling
Bulk density	1.45	
Soil type	Medium black soil	
Length of field, m	90	80

Table 1: Contd.,

Width of field, m		70	70
Area of field, m^2		6300	5600
Range of elevation height, cm		21 to -24	30.4 to -56
Standard deviation, cm	Before levelling	11.41	14.43
	After levelling	8.63	1.43

Table 2: Surveyed Readings (Reduced Levels in Meters) for the Field 1 before Laser Levelling

Grid Point	A	B	C	D	E	F	G	H	I	J
1	99.72	99.74	99.65	99.70	99.67	99.70	99.76	99.79	99.80	99.83
2	99.58	99.55	99.63	99.62	99.6	99.67	99.69	99.77	99.76	99.83
3	99.55	99.51	99.57	99.58	99.57	99.63	99.70	99.76	99.68	99.81
4	99.55	99.46	99.52	99.53	99.58	99.61	99.67	99.75	99.75	99.87
5	99.50	99.46	99.55	99.54	99.56	99.57	99.64	99.71	99.76	99.84
6	99.46	99.44	99.55	99.55	99.5	99.56	99.63	99.68	99.73	99.78
7	99.44	99.45	99.50	99.54	99.56	99.57	99.63	99.67	99.68	99.72
8	99.44	99.42	99.47	99.55	99.53	99.69	99.65	99.67	99.71	99.83

Table 3: Surveyed Readings (Reduced Levels in Meters) for the Field 2 before Conventional Levelling

Grid Point	A	B	C	D	E	F	G	H	I
1	99.33	99.37	99.4	99.47	99.45	99.52	99.45	99.53	99.56
2	99.27	99.29	99.41	99.36	99.40	99.46	99.47	99.55	99.50
3	99.28	99.30	99.35	99.35	99.40	99.39	99.42	99.45	99.49
4	99.29	99.23	99.30	99.27	99.38	99.38	99.4	99.41	99.55
5	99.05	99.12	99.21	99.20	99.32	99.3	99.39	99.39	99.47
6	99.10	99.17	99.16	99.09	99.29	99.23	99.35	99.36	99.34
7	99.30	99.20	99.29	99.05	99.2	99.19	99.28	99.26	99.36
8	99.00	99.01	99.00	99.05	99.08	99.12	99.15	99.18	99.25

Table 4: Surveyed Readings (Reduced Levels in Meters) for the Field 1 after Laser Levelling

Grid Point	A	B	C	D	E	F	G	H	I	J
1	99.67	99.66	99.65	99.64	99.64	99.63	99.65	99.66	99.67	99.67
2	99.67	99.65	99.64	99.63	99.64	99.64	99.64	99.65	99.65	99.66
3	99.65	99.64	99.63	99.62	99.63	99.62	99.63	99.64	99.64	99.65
4	99.64	99.64	99.63	99.63	99.63	99.62	99.63	99.63	99.63	99.64
5	99.63	99.62	99.62	99.62	99.63	99.63	99.63	99.64	99.64	99.65
6	99.63	99.63	99.63	99.64	99.63	99.63	99.64	99.64	99.65	99.66
7	99.62	99.62	99.62	99.63	99.64	99.63	99.64	99.65	99.66	99.66
8	99.61	99.62	99.63	99.64	99.64	99.63	99.64	99.65	99.67	99.67

Table 5: Surveyed Readings (Reduced Levels in Meters) for the Field 2 after Conventional Levelling

Grid Point	A	B	C	D	E	F	G	H	I
1	99.33	99.35	99.34	99.38	99.40	99.42	99.43	99.45	99.48
2	99.29	99.29	99.41	99.36	99.32	99.40	99.41	99.42	99.50
3	99.28	99.33	99.35	99.35	99.34	99.39	99.42	99.40	99.49
4	99.29	99.28	99.3	99.29	99.33	99.38	99.40	99.41	99.55
5	99.19	99.35	99.21	99.28	99.32	99.35	99.39	99.39	99.47
6	99.14	99.29	99.16	99.27	99.29	99.33	99.35	99.36	99.34
7	99.13	99.28	99.29	99.25	99.28	99.29	99.28	99.34	99.36
8	99.21	99.30	99.17	99.21	99.26	99.23	99.25	99.23	99.25

Table 6: Volume of Earthwork for the Traditional and Laser Leveled Fields

Particulars		Field 1	Field 2
Before levelling	Total volume of cut (m^3)	239	283.19
	Total volume of fill (m^3)	279.4	248.81
	Average	259.2	266.00
After levelling	Total volume of cut (m^3)	37.89	162.77
	Total volume of fill (m^3)	18.67	154.95
	Average	28.28	158.86
Reduction of earthwork, %		89.08	40.28

Table 7: Moisture Content and Uniformity Co-efficient for Traditional and Laser Levelled Fields after One Day Rainfall Event of 19 mm

Particulars	Laser Levelled Field	Traditional Levelled Field
Avg. moisture content, %	30.64	30.38
Standard deviation,%	3.73	9.11
Uniformity coefficient, %	92.90	75.90

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